A Novel Sol-Gel Derived SPEEK/Silicon Dioxide Composite Membrane for the Vanadium Redox Flow Battery

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Vanadium redox flow batteries (VRFBs) are industrial-scale batteries that are being considered for the storage of solar, wind, and other forms of renewable energy in power plants. The ion exchange membrane, which accounts for up to 40% of the overall cost, is a crucial component of the battery as its performance in transporting protons and preventing vanadium electrolyte crossover determines the voltage and coulombic efficiencies of the battery, respectively. A promising material for VRFB membranes is sulfonated poly (ether ether ketone) or SPEEK, due to its low cost and low vanadium ion permeability. In this study, in order to further decrease the permeability of the SPEEK membrane while increasing proton transport, a novel SPEEK/SiO2 composite membrane was synthesized by the sol-gel process using tetraethyl orthosilicate (TEOS) as the silica precursor. This composite membrane was shown to have a vanadium ion permeability 55% lower than that of the original SPEEK membrane, an improvement attributable to gap-filling by SiO2 in the SPEEK polymer matrix. Moreover, after SiO2 was introduced, a tenfold increase in proton conductivity was observed. The performance of the SPEEK/SiO2 composite in these tests was also an improvement over DuPont's Nafion® membrane, which is considered to be the industry standard. Finally, an economic analysis showed that the total cost for the SPEEK/SiO2 composite is 30% lower than that of Nafion® at scale. These results are very encouraging for the prospects of commercialization of VRFBs, as not only does this membrane significantly increase the efficiency, but it lowers the cost.

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